

January 28, 1886.

Professor STOKES, D.C.L., President, in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

The following Papers were read:—

- I. “On Local Magnetic Disturbance in Islands situated far from a Continent.” By Staff-Commander E. W. CREAK, R.N., F.R.S., of the Admiralty Compass Department. Received January 11, 1886.

[PLATE 1.]

It has been known for many years past that in the islands of St. Helena and Ascension observations of the three magnetic elements made at different stations gave remarkably divergent results, caused by some undefined local magnetic attraction.

Thus in the observations at St. Helena,* carried out under the auspices of the British Government in 1840–46, it was found that the observed inclination and intensity differed considerably at the two stations of Longwood and Sister’s Walk, $2\frac{1}{2}$ miles apart, and these again differed from those made on board ships in the anchorage.

This question of local magnetic disturbance is one which has engaged the attention of observers on continents and islands adjacent to them, in making magnetic surveys, when sometimes large areas have been found affected, and in others but very small ones. In such cases the normal values of the three magnetic elements have been obtained either by calculation from observations made in supposed undisturbed districts, or by graphic methods.

Thus in discussing the results of the magnetic survey of Scotland, made by the late Mr. Welsh in 1857–58,† Professor Balfour Stewart obtained the values of the local disturbances in the islands of Skye and Mull by calculating the normal lines of equal values of the magnetic elements for the mainland of Scotland, and extending beyond the adjacent islands on the west coast.

* See pp. 60, 61, vol. i of *Observations made at the Magnetical and Meteorological Observatory at St. Helena*. Published under the superintendence of Lt.-Colonel Sabine, 1847.

† Magnetic Survey of Scotland. See Report of British Association, 1859.

As an instance of unusual local disturbance in that part of the British Islands, the Compass Hill in the island of Canna,* near Skye, may be mentioned. Here the disturbance was sufficient to render a compass useless, and every small movement of the observing instruments gave different results.

For Ascension and St. Helena, and some other islands situated far from a continent, normal values of the magnetic elements have been obtained from observations at sea, and the object of this paper is to show how this may be done, and the resulting amount and nature of the disturbances in the islands visited.

The following values of the three magnetic elements observed at eleven islands represent the data collected for this purpose.

An inspection of them shows that they consist of a series of observations made on land, and which when made at different stations on the same island give divergent results caused by some local magnetic disturbance.

In order to obtain undisturbed or normal values, observations made on board ships, in which the amount of magnetic disturbance is known, have been adopted.

These normal values obtained on board ship are from observations made with the ship's head placed on eight or sixteen azimuths equally distributed round the horizon in the process called "swinging," all effects of the iron of the ship being eliminated by the methods set forth in the "Magnetical Instructions for H.M.S. 'Challenger.'"

It is important to note that these swingings took place in the neighbourhood of the island to be magnetically examined, and some small corrections had to be applied for differences of geographical position from the land stations. An example is given below of the method of deriving the normal values of the magnetic elements for a position on the green outside the Dockyard, Bermuda.†

The observations have been divided into two sections—first, those made on islands situated north of the magnetic equator, and in which the local disturbances have been generally found to be due to an excess of blue‡ magnetism above the normal; secondly, those made on islands situated south of the magnetic equator, in which the disturbances are generally caused by an excess of red magnetism.

Section I.—Islands situated North of the Magnetic Equator.

Bermuda Islands.

The Bermuda group is that on which a more complete series of

* Topographically and magnetically examined by the late Captain Evans, R.N.

† This position has been selected as the declination is there almost undisturbed. It appears to be a suitable place for future observations.

‡ In a freely suspended magnet the north-seeking end has red magnetism, the other end blue magnetism.

observations has been made than in the other islands, and as the results are remarkable they are the first to be discussed.

Table I shows some values of the declination observed previously to the "Challenger's" visit in 1873, but reduced to that epoch by allowing an annual change of 2' increasing. This annual change has been deduced from the best available observations at four stations.

Table I.—Declination at Bermuda, 1873.

Station.	Declination.	Difference from normal.	Observer.
Bastion C, Ireland Island	7° 24' W.	+ 0° 6'	Hill.
" "	8 00 "	+ 0 42	Barnett.
" "	6 26 "	- 0 52	Bodie.
Fort Cunningham Flagstaff.....	5 00 "	- 2 18	Barnett.
Hen Island Magazine	7 54 "	+ 0 36	"
(Near) lighthouse on Gibbs' Hill..	3 56 "	- 3 22	Bodie.
In the dockyard.....	7 30 "	+ 0 12	Hill.
Mount Langton.....	9 00 "	+ 1 42	Lefroy.
Anchorage { H.M.S. "Boscawen" ..	7 12 "	- 0 06	Bodie.
in Grassy { " "Cornwallis" ..	7 13 "	- 0 05	"
Bay { " "Pembroke" ..	7 19 "	+ 0 01	"
Green outside dockyard	7 18 "	Normal	"Challenger."

In Table II are recorded the magnetical results of the "Challenger" observed at Bermuda in 1873.

In Tables I and III will be found the differences between the observed magnetical elements and the normal values at a station on the green outside the dockyard, deduced from the results of swinging in a position 15 miles south of it.

Results of swinging at sea, corrected for effects of ship's iron.	Correction for diff. of geographical position.	Resulting normal values at green outside dockyard.
Declination, 7° 13' W.	+ 5'	7° 18' W.
Inclination, 65 18 N.....	+ 15'	65° 33' N.
Total force, 12·22.....	+ 0·03	21·25

In the accompanying diagram No. 1 the differences of declination are shown at each station, and in diagram No. 2 the differences of inclination and vertical force.

These results appear to point to the existence of a strong focus of blue magnetism situated above the position indicated by the dotted

H.M.S. "Challenger." Results of Magnetical Observations at the Bermuda Islands, 1873.

TABLE II.—Elements of Terrestrial Magnetism observed on Land.					TABLE III.—Differences of Magnetic Elements from the Normal Values.				
Place of observation.	Date.	Declina- tion.	Inclina- tion.	Total force.	Vertical force.	Declina- tion.	Inclina- tion.	Vertical force.	Remarks.
Tatam Island.....	1873. June 5	5° 56' W.	67° 02' 8" N.	..	..	-1° 22'	+1° 30'	..	Differences of the decli- nation at positions of swinging:—
Cricket ground, Somerset Island.....	April 7	5 09	65 44.2	12.345	11.259	-2 09	+0 11	+0.112	"Boscawen" = -0° 6'
Ducking stool, Mt. Langton	June 6	6 59	66 44.7	12.129	11.146	-0 19	+1 12	-0.001	"Cornwallis" = -0 5
Spanish Point.....	April 12	7 42	67 19.8	12.417	11.461	+0 24	+1 47	+0.314	"Pembroke" = +0 1
Governor's garden, Mt. Langton.....	" 11	8 54	67 20.0	12.362	11.410	+1 36	+1 47	+0.263	
Cemetery, Ireland Island..	" 9	5 58	66 27.6	..	..	-1 20	+0 55		
Sparyard, Ireland Island...	June 2	6 04	66 33.8	..	..	-1 12	+1 01		
Clarence Cove.....	" 3	9 57	66 44.0	12.443	11.435	+2 39	+1 11	+0.288	
Green outside dockyard ...	May 13	7 10	66 25.8	12.309	11.275	-0 08	+0 53	+0.128	
Ditto, assumed normal values reduced from re- sults of swinging.....	31	7 18	65 33.0	12.250	11.147	0 0			
Cobbler's Island.....	" June 11	8 08	..	..	..	+0 50			
St. George's, Button Island	April 12	7 15	..	..	..	-0 03			
Octopus Island.....	" 14	5 4	..	..	..	-2 14			
Barge Island.....	" 14	4 13	..	..	..	-3 05			
Wreck Hill.....	June 11	5 20	..	..	..	-1 58			
Boaz Island Bridge.....	" 4	5 11	..	..	..	-2 07			

line of the diagram, the red ends of the declination and dipping needles being attracted towards this focus with a force varying according to the place of observation.

Thus in the case of the declination at all stations situated to the north-east of the focus, the westerly declinations are seen to be in excess, and those to the south-west in defect of the normal value.

In the inclination and vertical force a great increase of value may be seen in passing from the seaward side of the islands towards the area enclosed by the dotted line of the diagram.

A portion of the disturbance just noticed may possibly be due to the ferruginous nature of the soil at Bermuda;* but this does not detract from the evidence just adduced of the existence of a strong focus of blue magnetism about the position assigned to it in the diagram.

In the eastern extremity of the group there are also evidences of local magnetic disturbance at the observing stations of Hen Island, Button Island, and Fort Cunningham.

Madeira.

	Declination.	Inclination.	Total force.	Observer.	
Casa Branca.....	16° 49' W.	56° 14' N.	8·784	H.M.S. "Challenger," 1873.	
"	17 8				
Cliff west of Loo Rock .	18 25				
" "	19 35	55 12	9·184		
" "	20 33				
<i>Normal values</i>	20 33	56 36	9·49		

The above observations of declination, made near Funchal, on the south side of the island, differ considerably (with one exception) from the normal, 3° 44' being the greatest difference.

There is also much disturbance in the inclination. In one position visited by the officers of the "Challenger," and at 1 foot above the ground, a value of 48° 46' was observed, and at the usual height of the observing stand—3¼ feet—over the same spot, 56° 18'. At two other positions 20 yards apart, the inclination differed 40'.

The greatest difference in the values of the total force is a decrease of 0·71 below the normal.

These results point to the importance of adopting an uniform height for the observing stand if comparable results are to be obtained.

* See "Remarks on the Chemical Analyses of Samples of Soil from Bermuda." By General Sir J. H. Lefroy. Bermuda, 1873.

Teneriffe. Canary Islands.

	Declination.	Inclination.	Total force.	Observer.
Sta. Cruz	21° 48' W.	55° 18' N.	9·546	H.M.S. "Chal-
<i>Normal values</i>	20 00	52 42	9·230	lenger," 1873.

At this island observations were only made at one land station, but there is evidence of a strong development of blue magnetism at the observing station.

Santa Cruz is on the east side of the island, and the westerly declination was found to be in excess of the normal value by $1\frac{3}{4}^{\circ}$. The inclination was $2\frac{1}{2}^{\circ}$, and the force 0·3 in excess of their respective normals.

St. Vincent. Cape de Verde.

	Declination.	Inclination.	Total force.	Observer.
Porto Grande	17° 3' W.	43° 6' N.	8·577	H.M.S. "Chal-
" "	18 52	..	..	lenger," 1876.
<i>Normal values</i>	19 54	42 52	8·540	

The observations were made on the west side of the island. Here the principal disturbance occurs in the westerly declination, which is nearly 3° in defect of the normal value. This points to the presence of increased blue magnetism on the inland side of the observing station.

The inclination and force are but little affected.

St. Paul Rocks. (Atlantic Ocean.)

	Declination.	Inclination.	Total force.	Observer.
Land station.....	16° 22' W.	22° 32' N.	7·00	H.M.S. "Chal-
<i>Normal values</i>	15 51	22 30	6·94	lenger," 1873.

At these rocks the declination and total force are slightly disturbed, the inclination agreeing well with the normal.

Sandwich Islands.

	Declination.	Inclination.	Total force.	Observer.
Honolulu	9° 34' E.	39° 57' N.	8·512	H.M.S. "Challenger," 1875.
<i>Normal values</i>	8 47	39 32	8·450	
Hilo, Coconut Island	7° 29' E.	38° 39' N.	8·698	Ditto
<i>Normal values</i>	8 15	37 32	8·330	

At Honolulu blue magnetism is predominant at the observing station, which is on the west side of the island, the easterly declination being $\frac{3}{4}^{\circ}$ in excess of the normal. The inclination and force are slightly increased.

A marked difference is seen between the observed declinations at Honolulu and Hilo. At the first-named place the easterly declination observed on the *west* coast is increased $\frac{3}{4}^{\circ}$, whilst at the latter the easterly declination observed on the east coast is *decreased* $\frac{3}{4}^{\circ}$.

The large increase in the observed inclination and force at Hilo above the normal, coupled with the diminished declination, point to a strong development of blue magnetism in that portion of the island visited.

This concludes our list of islands in which, with the exception of Madeira, blue magnetism appears to predominate. Madeira, however, requires a much more extended series of observations to be made on its shores before any conclusions can be drawn as to the prevalence of either blue or red magnetism.

Section II.—Islands situated South of the Magnetic Equator.

Ascension.

	Declination.	Inclination.	Total force.	Observer.
Georgetown	23° 6' W.	7° 56' S.	6·133	H.M.S. "Challenger," 1876.
Green Mountain	22 32	9 57	6·217	
<i>Normal values</i>	22 41	7 37	6·100	

The observations at this island are complete at two stations. At Georgetown, on the coast, there is but little local disturbance, but at the Green Mountain Station the observed inclination exceeds the normal in value by $2\frac{1}{3}^{\circ}$, the force by 0·12 (nearly), thus pointing to an excess of red magnetism.

St. Helena.

	Declination.	Inclination.	Total force.	Observer.
Longwood Magnetic Observatory	22° 48' W.	21° 21·7' S.	6·030	Observatory results.
Sister's Walk* .....	..	$\left\{ \begin{array}{l} 18 \ 16 \\ 20 \ 3 \end{array} \right.$	6·287	Ross } 1840.
Castle gardens.....	19 38	..	..	Crozier } 1840.
At the anchorage....	22 17	17 55	..	Ross, 1840.
<i>Normal values</i>	22 53	18 37	6·075	Dupetit Thouars, 1839. Ross, 1840.

At Longwood Magnetic Observatory the declination is apparently undisturbed, whilst in the Castle Gardens it differs $3\frac{1}{4}^{\circ}$ from the normal value. The inclination at Longwood differs $2\frac{3}{4}^{\circ}$ from the normal, pointing to the presence of an excess of red magnetism in that locality. The total force is not much disturbed.

At Sister's Walk the inclination at two stations, 50 yards apart, differs $1\frac{3}{4}^{\circ}$, one being in excess of the normal by $1\frac{1}{2}^{\circ}$ nearly, the other twenty minutes in defect; the larger disturbance being due to red magnetism. The total force is increased as much as 0·2.

The result of the inclination by Dupetit Thouars, which is 42' below the value derived from Ross's observations, seems to indicate that a lower value might be accepted as the normal.

Tristan d'Acunha.

	Declination.	Inclination.	Total force.	Observer.
Near Julia Point	23° 5' W.	40° 40' S.	Not observed	H.M.S. "Challenger," 1873.
<i>Normal values</i>	21 15	41 42	6·36	

The observing station at this island was situated on the N.W. coast near some cliffs extending to the eastward. The westerly declination is increased about $1\frac{3}{4}^{\circ}$ above the normal, but as the inclination is slightly affected by blue magnetism, it is uncertain whether it is the red magnetism in the adjacent cliffs to the eastward repelling the red end of the compass needle, or the blue magnetism near it which causes the increase of the declination.

* At Sister's Walk, Crozier's observing station was 50 yards S.S.E. of Ross' station. The dip circles were interchanged at the time to prove the difference observed was not due to instrumental error.

Kerguelen Island.

	Declination.	Inclination.	Total force.	Observer.
Christmas Harbour ..	33° 38' W.	70° 50' S.	11·032	H.M.S. "Challenger," 1874.
Howe's Foreland ....	..	72 0	..
<i>Normal values</i>	34 35	70 53	11·003	
Accessible Bay	33° 34' W.	H.M.S. "Challenger," 1874.
Betsy Cove	34 0	71° 47' S.	11·422	
<i>Normal values</i>	34 57	71 7	11·087	
Observatory Bay	35° 48' W.	71° 56' S.	11·143	Perry, 1 Jan., 1875.
Swain's Haulover....	..	71 0	10·288	
Thumb Peak.....	..	71 7	..	
Hog Island	35 54	H.M.S. "Challenger," 1874.
<i>Normal values</i>	35 20	71 21	11·171	

The "Challenger" was not swung in the neighbourhood of Kerguelen Island, and the normal values have therefore been derived from the results of single observations made at sea between the swinging, at the Cape of Good Hope, and that in lat. 63° 30' S., long. 90° 47' E. They are therefore less exact, but sufficiently so for the purpose of showing that the disturbances on the island proceed from red magnetism.

Thus, at Christmas Harbour, Accessible Bay, and Betsy Cove, where there was high land to the westward of each observing station, the westerly declination is about 1° less than the normal. At Howe's Foreland and Betsy Cove the inclination is increased, and at the latter place the total force is considerably above the normal. At Observatory Bay and the adjacent stations the disturbance is comparatively of a moderate amount, except in the total force at Swain's Haulover, which shows an unusually large diminution.

Juan Fernandez.

	Declination.	Inclination.	Total force.	Observer.
Near Fort St. Juan Bautista .....	..	39° 40' S.	8·138	H.M.S. "Challenger," 1875.
<i>Normal values</i>	16° 40' E.	37 54	7·860	

The sea observations from which the normal values have been deduced were made at two positions—one before, the other after the ship's arrival at Juan Fernandez.

The above observations, like those at St. Helena and Ascension, show the existence of an excess of red magnetism above the normal from the increased values of the inclination and total force.

The general results of the observations just discussed is to show that in islands far from a continent and north of the magnetic equator, the local disturbances of the three magnetic elements are caused by an excess of blue magnetism above the normal values due to the position of the islands on the earth considered as a magnet. South of the magnetic equator red magnetism is in like manner predominant.

Considering, however, that the observations were made with the instruments between 3 and 4 feet above the ground, the disturbances are not large.

As an instance of large disturbance the results obtained at the bluff, Bluff Harbour, in the South Island, New Zealand, may be mentioned. In 1857, during the land survey by the local government officials, the following values of the declination were observed.*

On the summit of the bluff.....	.....	6° 54' E.
30 feet north of the same position.....	.....	9 36 W.
„ west	„	5 04 E.
„ east	„	46 44 E.
Normal from sea observations.....	.....	16 20 E.

On the summit of the bluff there was thus shown to be a strong focus of red magnetism.

During the survey of the South Island by the officers of H.M.S. "Acheron," it was found necessary to give up the use of compass-bearings at this place, and adopt the plan of observing nothing but true bearings.

The evidences of local magnetic disturbance form a great difficulty in estimating the values of the secular change in these islands for past years. For example, Madeira may be mentioned, where it has been seen that a change in position of a few feet gave very different results of the inclination, and even at the same position the height at the observing instrument above the ground must be taken into consideration if comparable results are to be obtained.

Before concluding this paper, I desire to draw attention to the following remarks on this subject of local magnetic disturbance.

Firstly, reasons have been given for believing "that terrestrial magnetism is not produced in any important degree by magnetic forces external to the earth."†

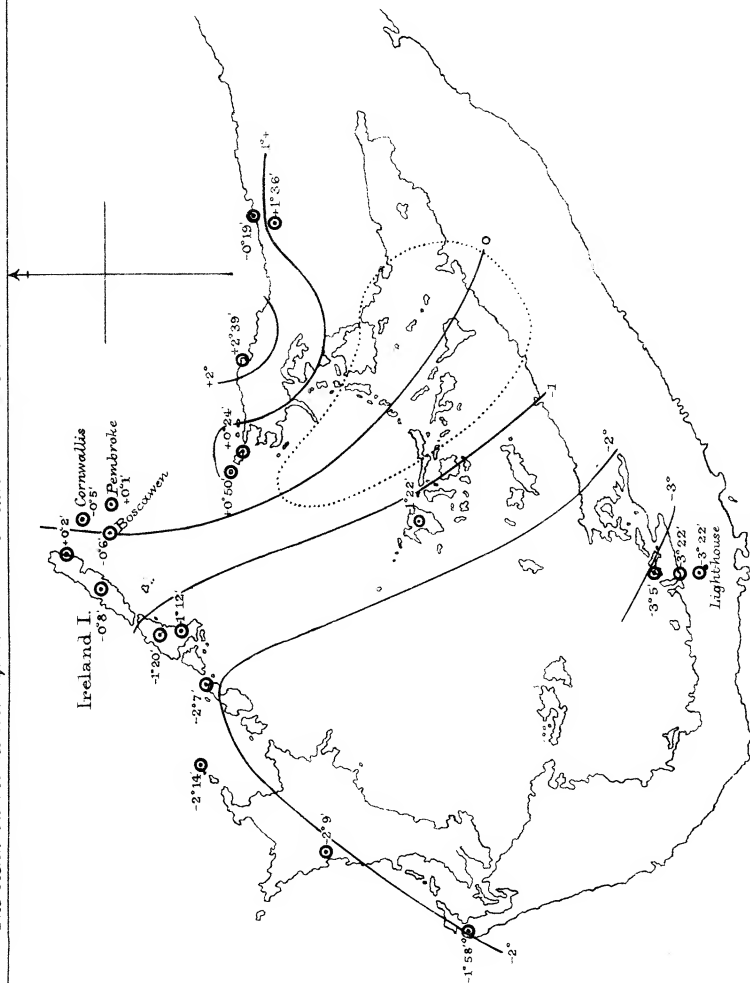
* "Transactions New Zealand Institute," 1873, vol. vi, p. 7.

† See "Treatise on Magnetism," p. 100, par. 43, by Sir G. B. Airy, K.C.B., Ast. Royal, 1870.

Bermuda Islands. Western Portion.

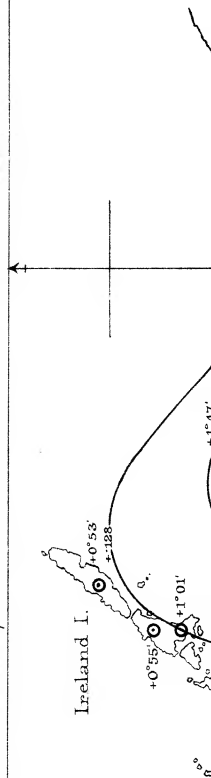
Declination { The Figures in this plan are taken from Tables I and III.
The dotted line shows assumed position of blue focus.

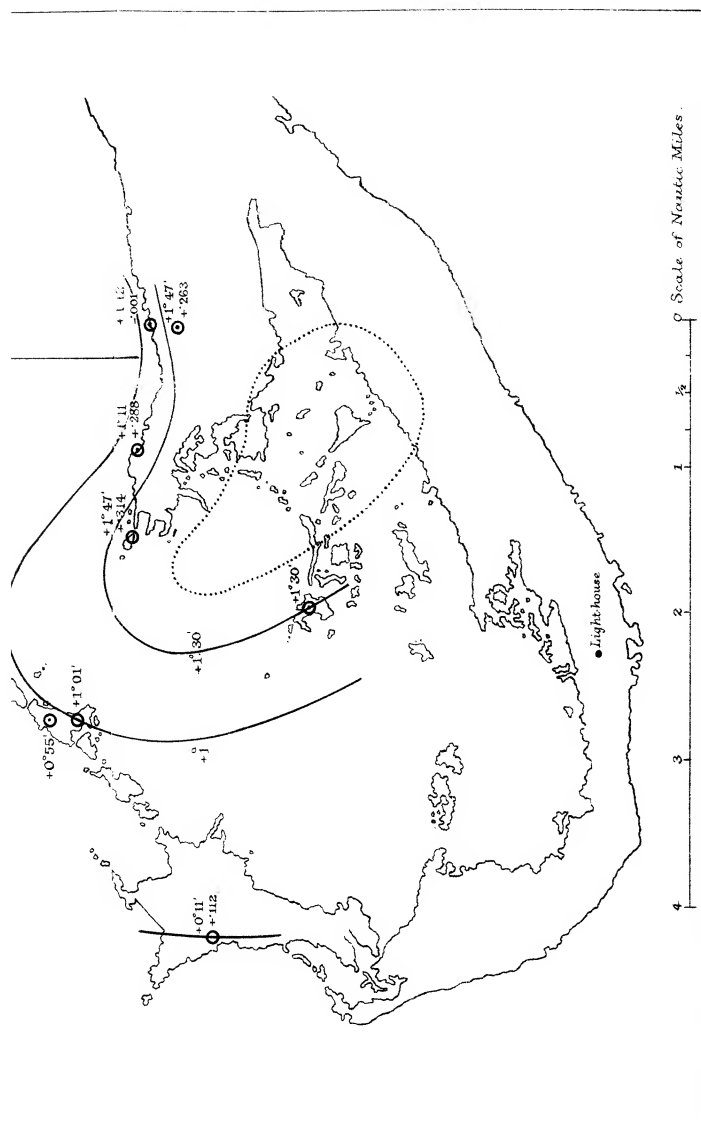
The black curves denote equal values of disturbance in the Declination


$$\frac{\dot{N}}{N}$$

Inclination
Vertical Force

The black curves denote equal values of disturbance in the Inclination.





West, Newman & Co lith.

Secondly, "that terrestrial magnetism does not reside in any important degree on the earth's surface" "and therefore the source of magnetism must lie deep."*

In view of these reasons and the results obtained from the observations recorded in this paper, I draw the possible conclusion : That the increase of magnetic force observed in the islands under discussion proceeds from portions of those islands which have been raised to the earth's surface from the magnetised part of the earth, forming the source of its magnetism.

II. "Description of some Remains of the Gigantic Land-Lizard (*Megalanian prisca*, Owen) from Queensland, Australia, including Sacrum and Foot-Bones. Part IV." By Sir RICHARD OWEN, K.C.B., F.R.S., &c. Received January 13, 1886.

(Abstract.)

The author, continuing to receive through the kindness of Dr. Bennett, F.L.S., of Sydney, New South Wales, and of Mr. George F. Bennett, Corr. M. Zoological Society, Toowoomba, Queensland, Australia, fossil remains of *Megalanian* from a drift-bed of King's Creek, selected therefrom specimens contributing to the restoration of *Meg. prisca*, and which he had not obtained at the dates of communication of the papers to the Royal Society which have appeared in the "Phil. Trans." for the years 1864, 1880, and 1881.

These specimens add to the characters of the sacrum, and give those of the terminal segment of one of the limbs of the extinct horned Saurian.

The metapodial series are remarkable for the great breadth in proportion to the length of the bone ; that of one of the digits being as broad as long, and testifying to its character as a metatarsal by the distal trochlea for the articulation of a proximal phalanx. The digits were unguiculate, indicative of terrestrial life and locomotion.

The subjects selected for description in the present paper are illustrated by drawings of the natural size, which accompany the text.

* See *idem*, p. 101, par. 44.

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Discussion

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